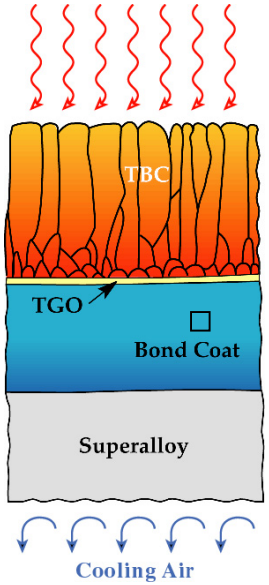
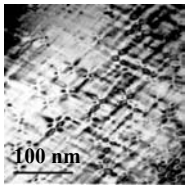
"Use of Microsample Testing to Characterize and Model Bond Coat Performance and TBC Life"

K.J. Hemker, Johns Hopkins University, Grant No. DMR9986752

NSF GOALI with GE Aircraft Engines



Before



After

B2 – transforms -> Martensite as a result of thermal cycling

- **First-ever measurements of bond coat mechanical properties achieved with high temperature microsample tensile testing.**
- **Uncovered the fact that the bond coat transforms from B2 to $L1_0$ martensite upon thermal cycling.**
- ***In situ* TEM observations and X-ray diffraction indicate that this transformation occurs each time the jet engine is cycled.**
- **Finite element simulations of the TBC indicate that this transformation promotes spallation, which governs TBC life.**

*M. W. Chen, R. T. Ott, T. C. Hufnagel, P. K. Wright and K. J. Hemker, "Microstructural evolution of platinum modified nickel aluminide bond coat during thermal cycling", Surface and Coatings Technology, **163-164** (2003) 25-30.*

*Deng Pan, M.W. Chen, P.K. Wright and K.J. Hemker, "Characterization of a Diffusion Aluminide Bond Coat for Thermal Barrier Coatings", Acta materialia, **51** (2003) 2205-2217.*

*M.W. Chen, K.T. Livi, P.K. Wright and K.J. Hemker, "Microstructural Characterization of a Platinum Modified Diffusion Aluminide Bond Coat for Thermal Barrier Coatings", Metallurgical and Materials Trans., **34** (2003) 2289-2299.*

*M.W. Chen, M. L. Glynn, R. T. Ott, T. C. Hufnagel and K.J. Hemker, "Martensitic transformation and transformation strain in a thermally cycled platinum modified diffusion aluminide bond coat", Acta materialia, **51** (2003) 4279-4294.*

M.L. Glynn, M.W. Chen, K.T. Ramesh and K.J. Hemker, "The Influence Of A Martensitic Phase Transformation On Stress Development In Thermal Barrier Coating Systems", Metallurgical and Materials Trans., in press (2003).

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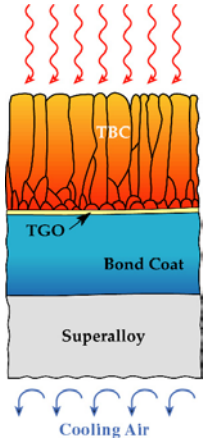
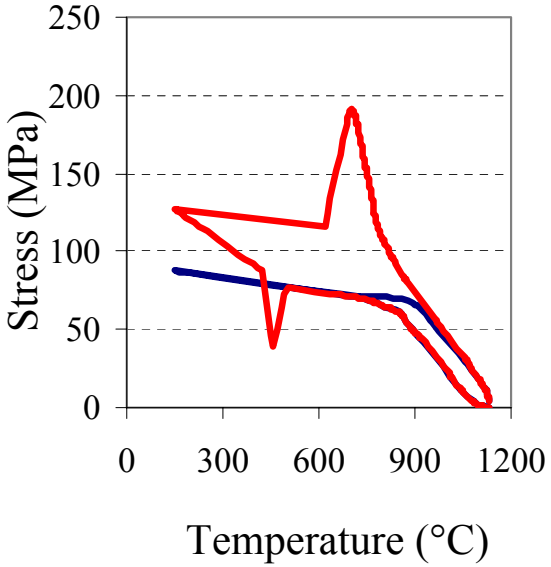
- TBC's offer the greatest potential for increasing the performance of gas turbine engines.
- Microsample preparation and testing have allowed us to measure bond coat mechanical properties and to show that they change dramatically as a result of thermal exposure.
- TEM and X-ray analyses have uncovered the fact that these bond coats transform to an $L1_0$ martensite during service, e.g. each time the jet engine is started.
- Finite element (FE) models have been used to show that this transformation plays an important role in determining the overall life of the TBC system.





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Educational Activity:

- 5 undergraduate research assistants: Dan Tobin (03), Mike Taylor (03), David Sparks (04), Chris Kovalchick (06), Peter Lillehoj (06).
- 3 graduate students: Michael Glynn (Ph.D. 12/02), Deng Pan (Ph.D. 3/03) and Cristian Cionea.
- 1 research professor: Dr. Mingwei Chen (partially supported).

Professional Activity:

- Chair, Editorial board, *Metall. Mater. Trans.* (02-03).
- 11 invited presentations on GOALI research.
- 12 student presentations on GOALI research.

Industrial Outreach

- GE Aircraft Engines: Ken Wright (co-PI), Joe Rigney, Ram Darolia.
- 4 visits to GE Aircraft Engines.
- Ken Wright involved in PhD defense at JHU.

Hemker research group:

L to R: Dan Butler*, Dan Gianola*, Professor Kevin Hemker, Piyush Jain, Rob Thompson, Cristian Cionea*, Dr. Jarir Akkta, Dr. Mingwei Chen

Undergraduate research assistants: Chris Kovalchick*, Peter Lillehoj*

* supported by NSF